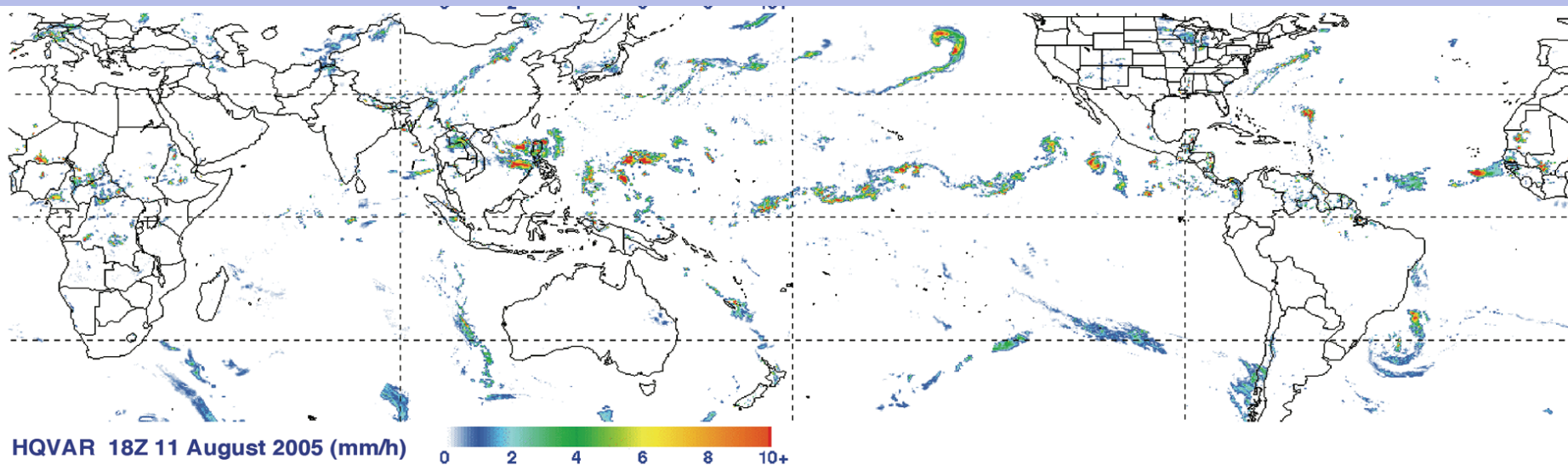# Multi-Sensor Precipitation Analysis Development in the U.S.
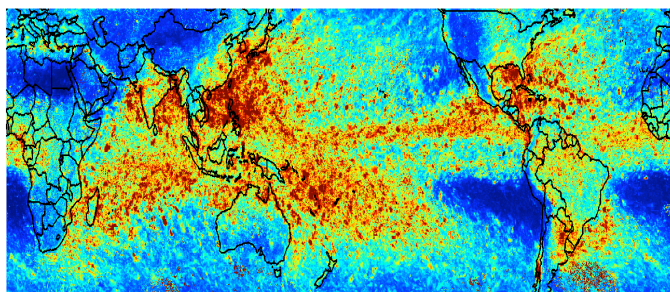
Robert Adler

TRMM Project Scientist
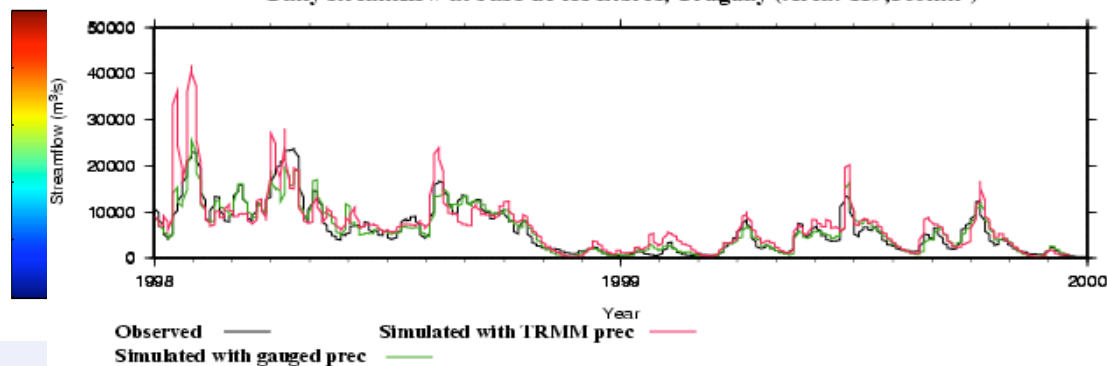
NASA/Goddard, Laboratory for Atmospheres

HQVAR 18Z 11 August 2005 (mm/h)

0   2   4   6   8   10+

Largest Daily Rainfall out of 8–year 3B42 Daily Rainfall (mm/day)

Daily streamflow at Paso de los Libres, Uruguay (Area: 189,300km^2)

Streamflow (m^3/s)

1998   1999   2000

Year

Observed ———   Simulated with TRMM prec ———

Simulated with gauged prec ———

Satellite-based High Time Resolution (≤ 3hr) Precipitation Analysis

- Development driven by <u>research needs</u> to study weather variations, extreme precipitation events, diurnal variations and <u>applications</u> to hydrology, validation of numerical models and hazard warnings

- Techniques have been developed by <u>NOAA, NASA, Navy and universities</u> in the U.S.   NASA's Precipitation Program has, at least partially, supported all these efforts with funding.

- <u>TRMM has had a multi-satellite standard product (3B42)</u> from the beginning (1998) that has evolved from a daily product to the current 3-hr precipitation analysis.

- Recent developments have used <u>TRMM, AMSR, SSM/I, AMSU</u> and <u>geosynchronous IR</u> satellite observations and gauges. *[Note that the data is from NASA, NOAA, DoD, JAXA--free flowing data has led to success in this area]*

- Products are being produced in both <u>real-time</u> (usually a few hours after observation time) and in a <u>research</u> (or post real-time) mode.

Four Quasi-Global U.S. Products

- <u>Navy Research Laboratory (NRL)</u>--Microwave calibrated Geo-IR produced in real-time [Turk]

- <u>PERSIANN (U. of California, Irvine)</u>--Microwave calibrated Geo-IR [Sorooshian, Hsu]

- <u>CMORPH (NOAA/NCEP/CPC)</u>--Microwave data interpolated ("morphed") using geo-IR motion [Janowiak, Joyce]

- <u>TMPA [3B42] (NASA/Goddard)</u>--Microwave data (with IR filling gaps) calibrated by TRMM in 3-hr windows [Adler, Huffman]
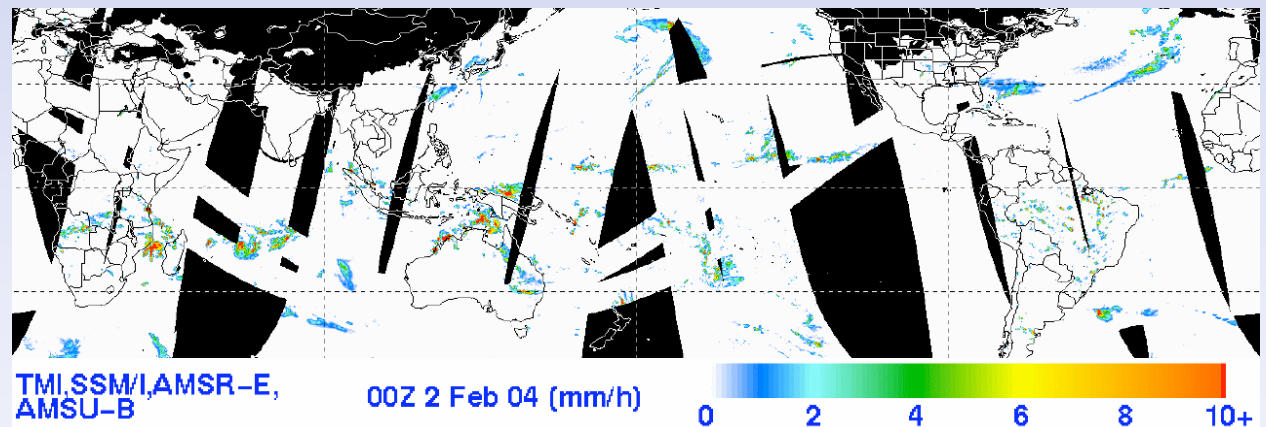
Current Microwave Constellation

(3-hour window)

Combined "high quality" (conical scanning) microwave data coverage: Averages 55% with TRMM, AMSR-E and 3 SSM/I's

TMI,SSM/I,AMSR-E   00Z 2 Feb 04 (mm/h)   0   2   4   6   8   10+
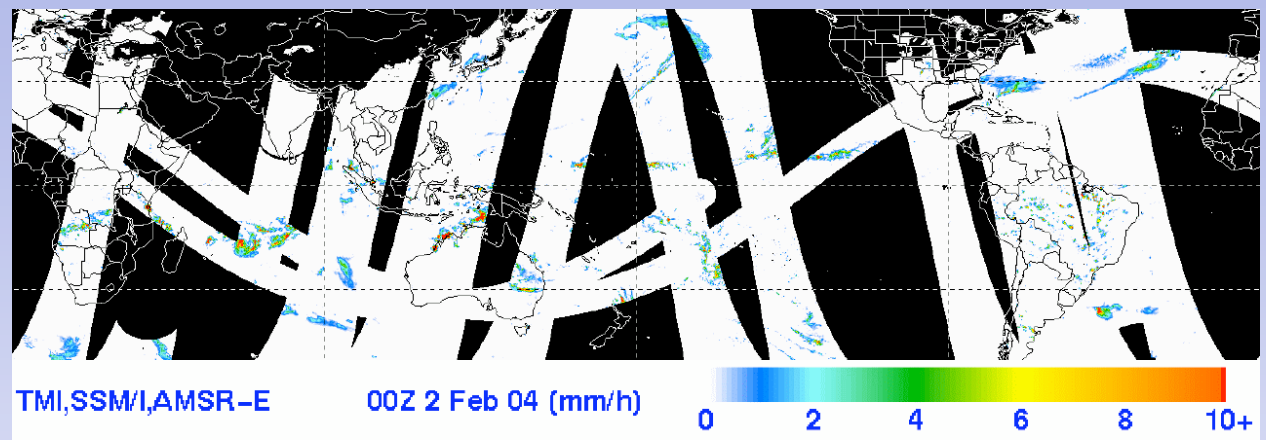
Addition of 3 AMSU-B's: Total coverage averages ~ 85% (lower quality over ocean)

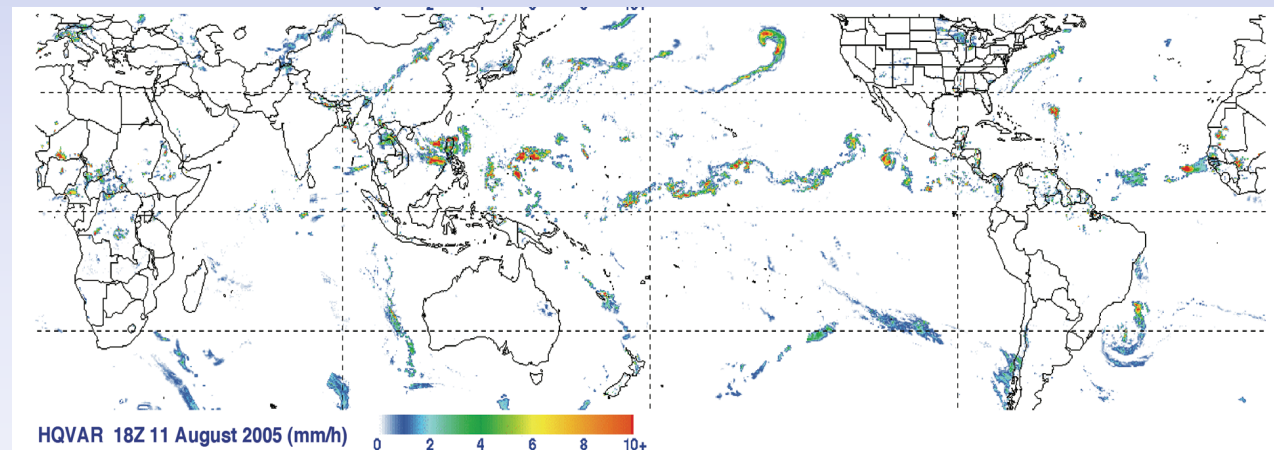TMI,SSM/I,AMSR-E, AMSU-B   00Z 2 Feb 04 (mm/h)   0   2   4   6   8   10+

The NASA TRMM Multi-Satellite Precipitation Analysis
(TMPA or 3B42 [TRMM product number]) [Adler/Huffman]

3-hr window with passive microwave (gaps filled with Geo-IR) calibrated by TRMM
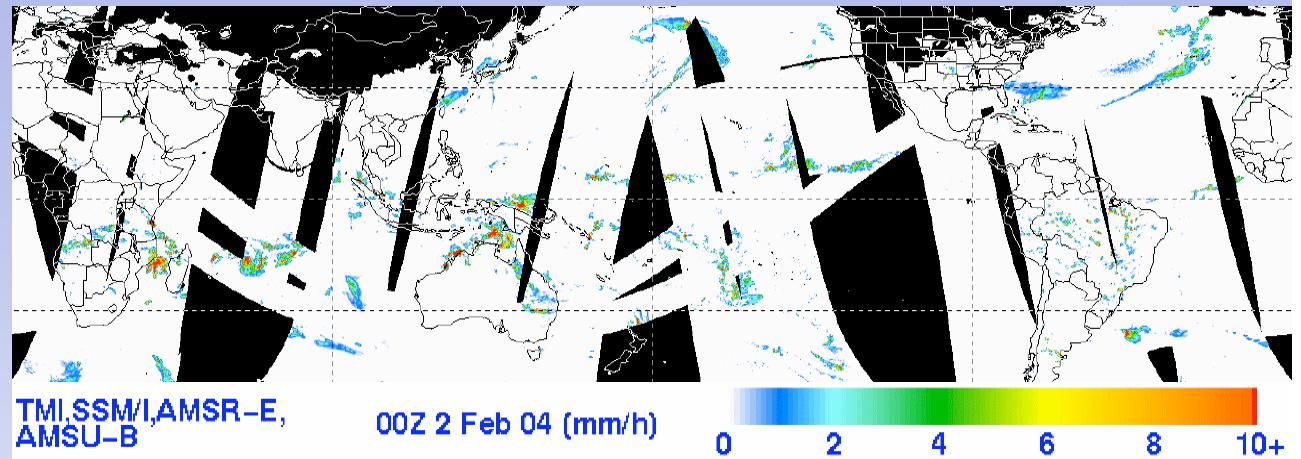
Research product uses PR information and monthly gauges

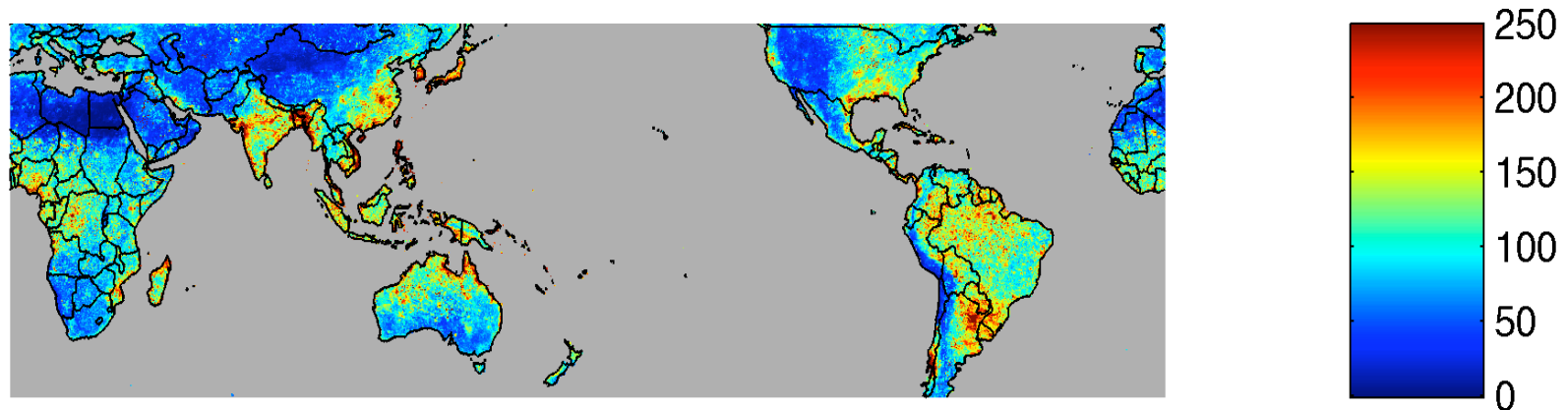*Almost 9 years ('98-06')of 3-hr analysis available--produced at TSDIS. Most highly requested TRMM product from DAAC*

Use TMPA for Analysis of Extreme Precipitation Events

Largest Daily Rainfall out of 8–year 3B42 Daily Rainfall (mm/day)
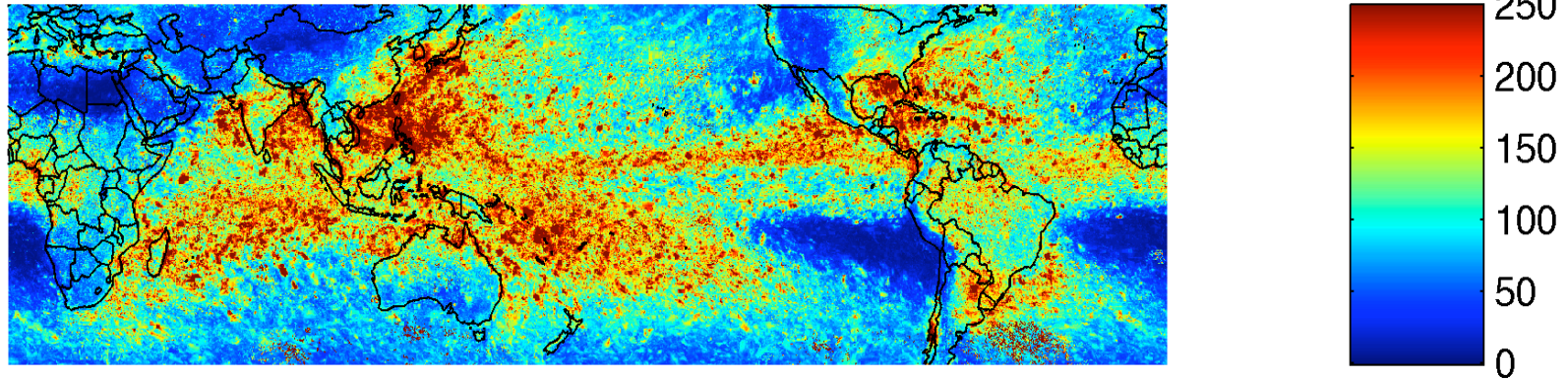
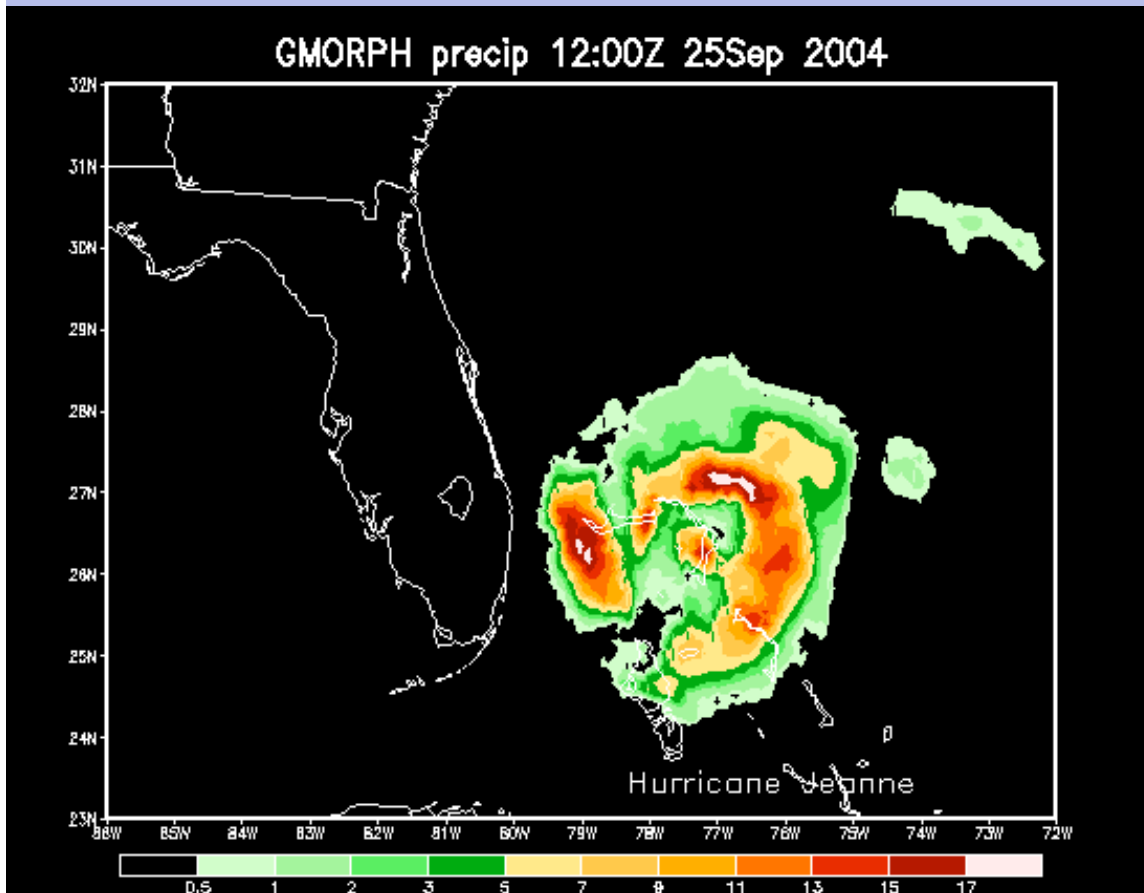## Largest Daily Rainfall Over 8-year Period

Largest Land Daily Rainfall out of 8–year 3B42 Daily Rainfall (mm/day)

Extremes in daily rainfall related to ENSO--
Curtis et al. 2007, J. Hydromet.

CMORPH
NOAA/NCEP/Climate Prediction Center
"Morphing" technique [Janowiak/Joyce]

GMORPH precip 12:00Z 25Sep 2004

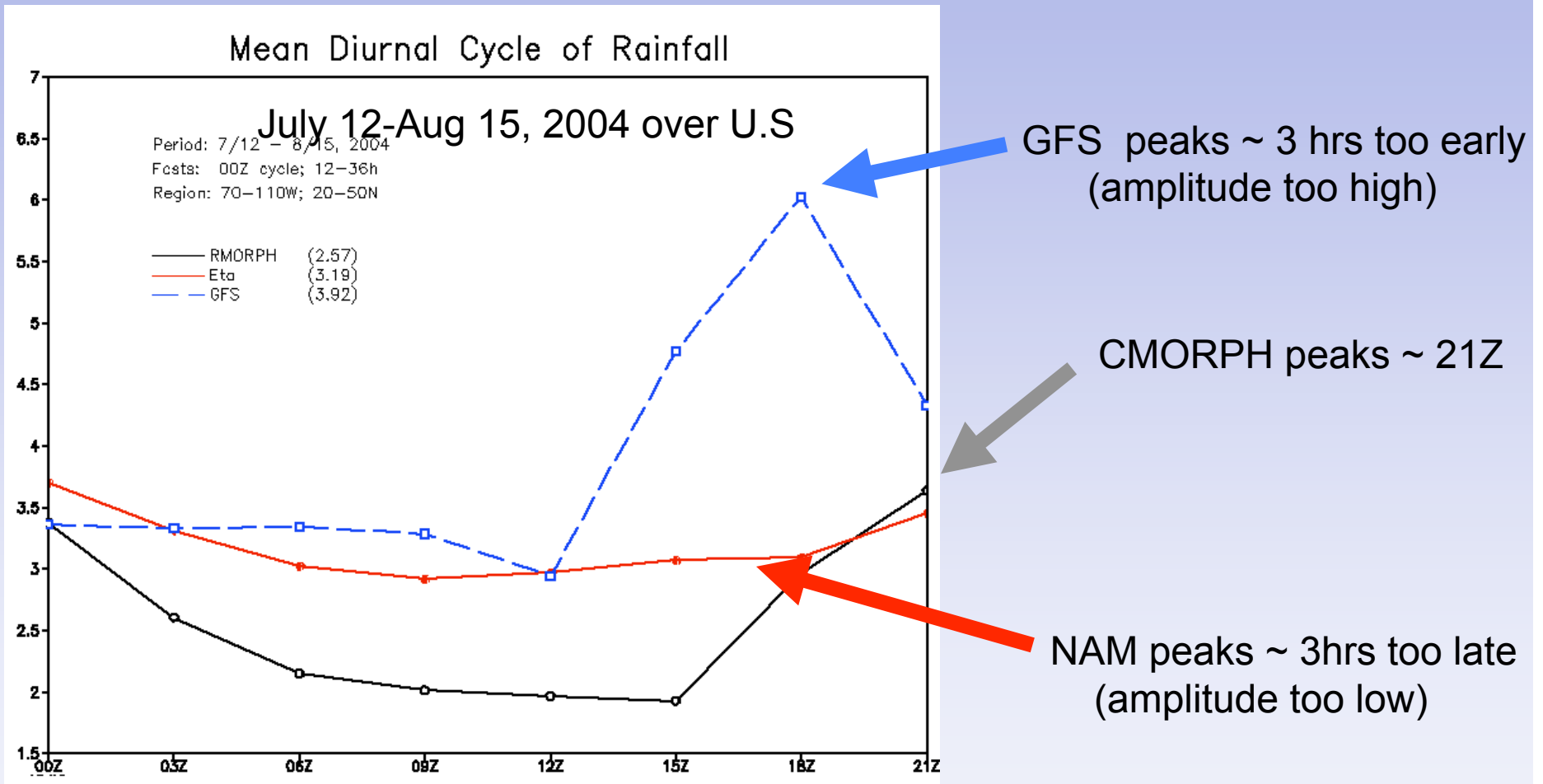Hurricane Jeanne

0.07^o x 0.07^o lat/lon / _ hr

Uses IR or model winds to propagate & 'morph' precipitation identified by passive microwave

Dec 2002 – present; extending back to ~1998

Inclusion of gauges in future

CMORPH

Science Application: Janowiak et al. (*J. Climate,* 2007)

Mean Diurnal Cycle of Rainfall

July 12-Aug 15, 2004 over U.S

Period: 7/12 – 8/15, 2004
Fcsts: 00Z cycle; 12–36h
Region: 70–110W; 20–50N

RMORPH (2.57)
Eta   (3.19)
GFS   (3.92)

GFS peaks ~ 3 hrs too early (amplitude too high)

CMORPH peaks ~ 21Z

NAM peaks ~ 3hrs too late (amplitude too low)
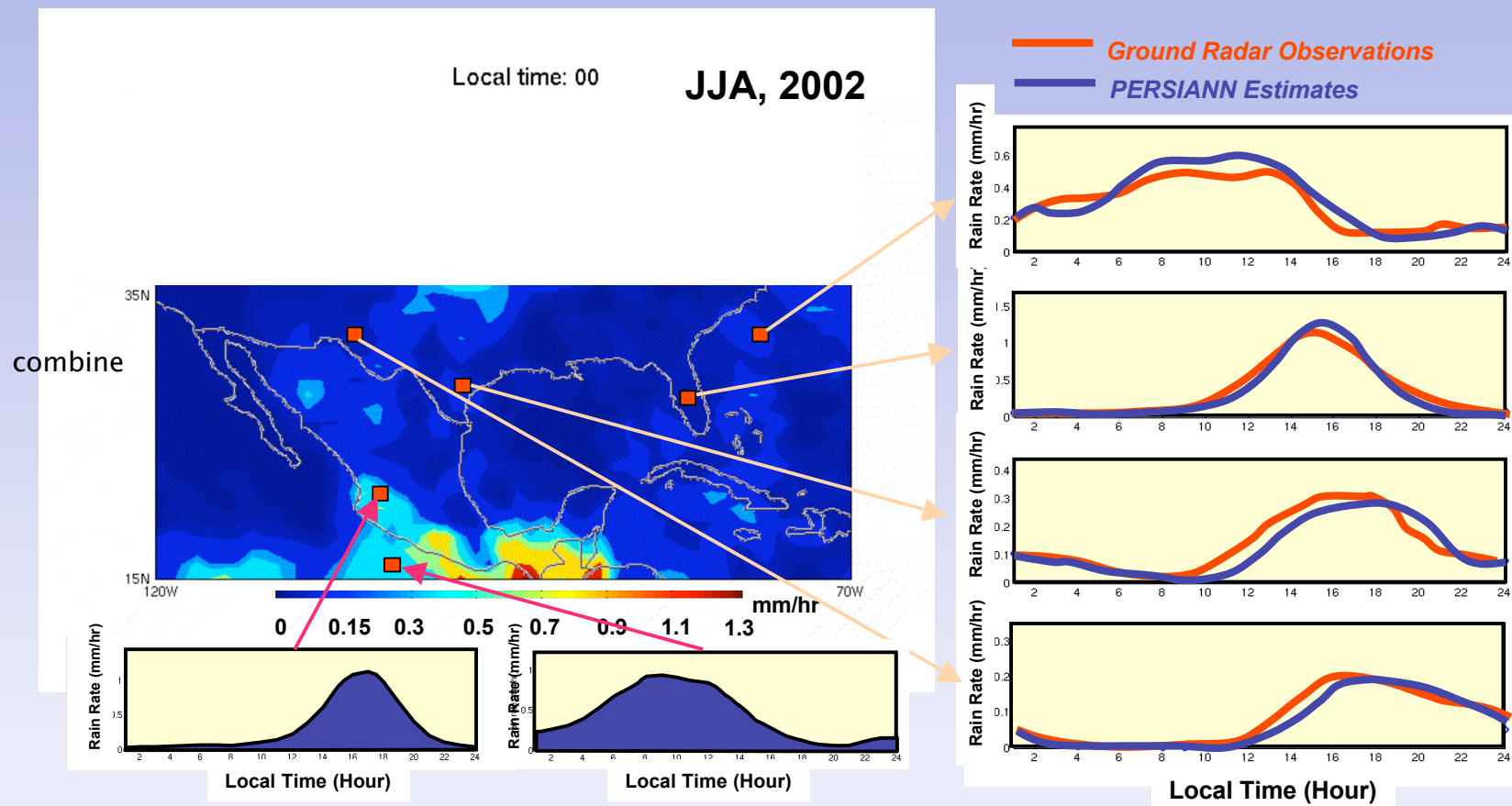
Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN)

U. Of California, Irvine (Sorooshian, Hsu et al.)

PERSIANN System "Estimation"

Satellite Data

Global IR

High Temporal-Spatial Res. Cloud Infrared Images

MW-RR
(TRMM, NOAA, DMSP Satellites)

MW-PR Hourly Rain Rates

Sampling

ANN

Feedback

Error Detection

Ground Observations

GPCC & CPC Gauge Analysis

Gauges Coverage

Products

Hourly Global Precipitation Estimates

Hourly Rain Estimate

Quality Control

Merging

Merged Products
- Hourly rainfall
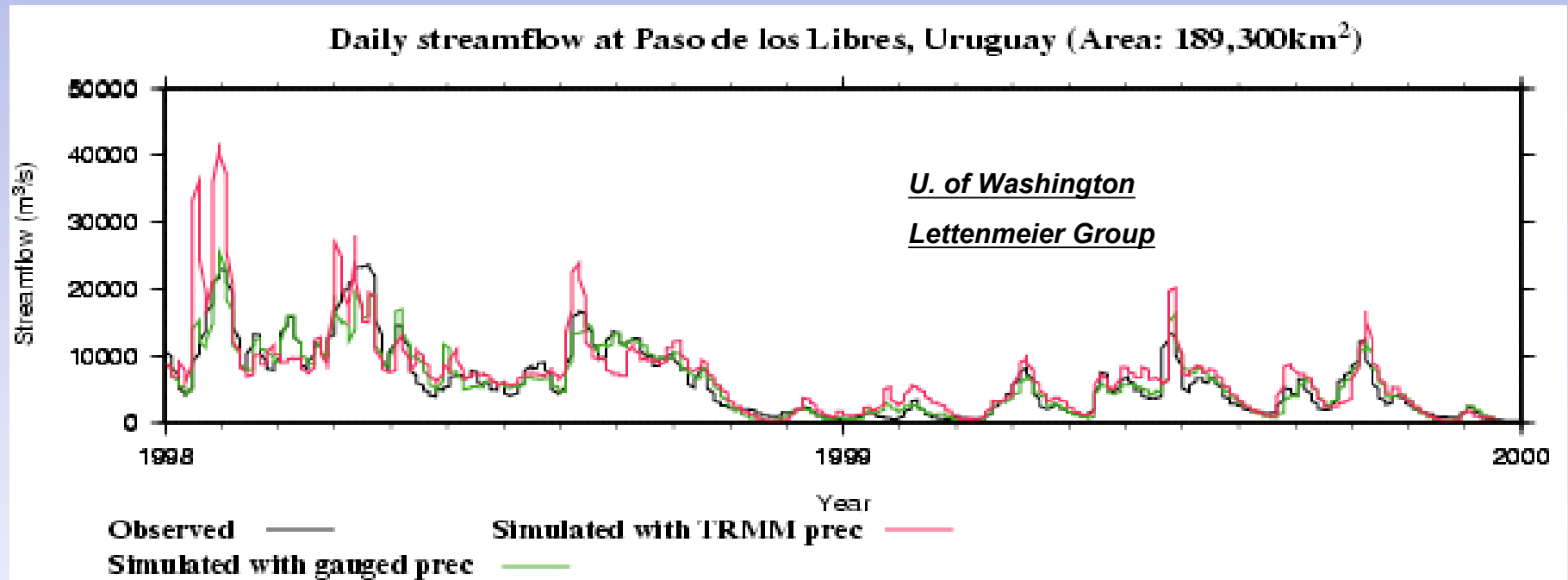- 6 hourly rainfall
- Daily rainfall
- Monthly rainfall

Diurnal Cycle of PERSIANN Monsoon Rainfall

Applications: Hydrological Analysis/Forecasting

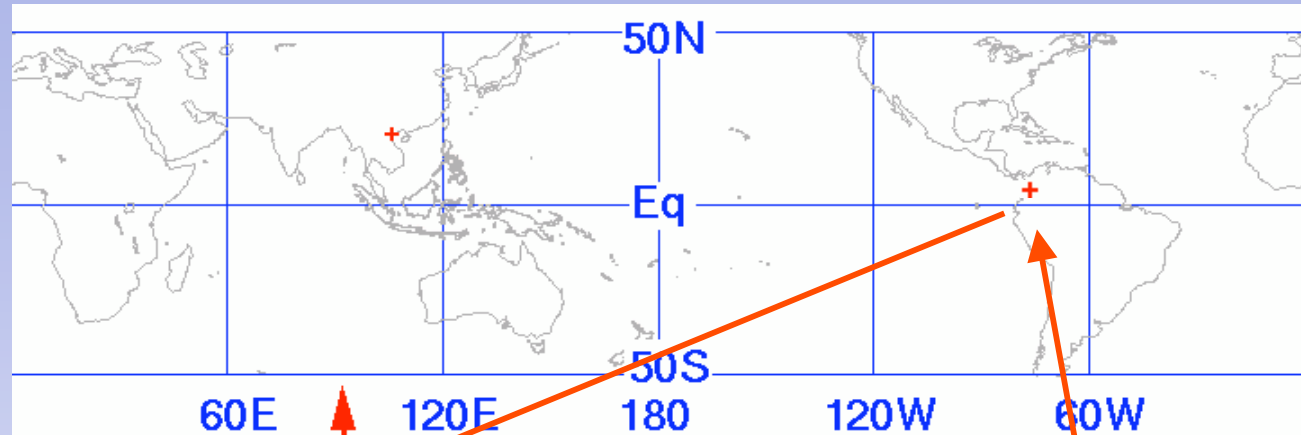## Watershed-based VIC Simulation (1998-1999): La Plata Basin

Researchers in U.S. and elsewhere are working toward global hydrological analysis and flood forecasting--these data sets are the basis for those efforts!

Landslide Analysis

Heavy rain also related to landslides-
Experimental techniques combining satellite rain and surface information are being developed for analysis and possible forecasting

Rainfall Map ➜ Intensity-Duration ➜ Susceptibility/ ➜ Landslide Warning

Rainfall Trigger
Intensity-Duration

Sliding Probability

Decision Making Inventory Data

35   75   125   175 mm
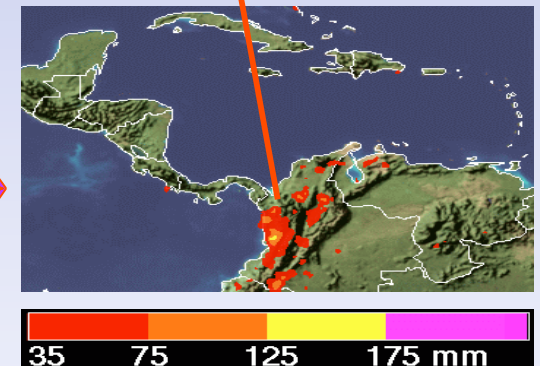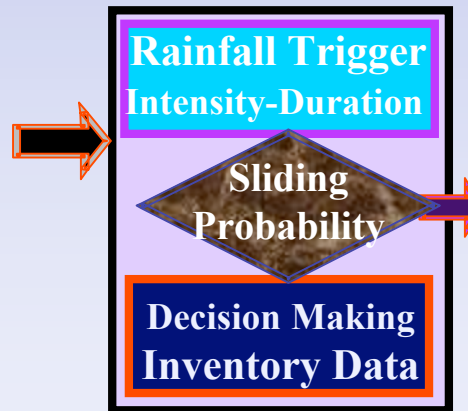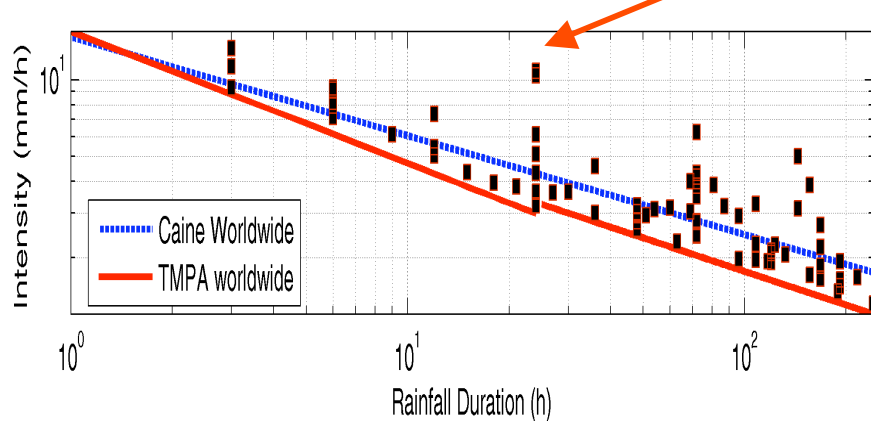
TRMM Near Real-Time Rainfall at location 76.875 W, 4.125 N, April 13, Columbia
1) the last 24 hour rainfall accumulation > 103mm
2) The Susceptibility Map shows high or very high susceptibility

News Report: 13 Apr 2006, **At least 34 people missing in Colombian mudslide**

Future, Challenges and GPM

- Techniques will continue to develop--use of <u>gauges</u> (even sfc. radar nets), <u>new forms of satellite data</u> (e.g., scatterometer), new analysis techniques. <u>Inter-comparisons</u> will help give direction.

- Development of <u>error information</u> critical for optimal use.

- <u>Limitations</u> of current analyses--biases over land, underestimation of orographic rain, middle and high latitude over land is missing in cool season.

- <u>GPM</u> will give <u>improved calibration</u> or adjustment of rainrates in <u>tropics</u> and <u>critical new information</u> for development and validation of <u>middle and high latitude estimates</u>.

- <u>Continuation of inclined orbit calibrator</u> (and latitude expansion thereof) is <u>necessary for success of high time resolution products</u>. <u>Constellation satellite</u> (especially in tropical orbit) is very important to retain or improve sampling in low latitudes.